MODIFICATION OF PERVIOUS CONCRETE USING STEEL SLAG AS AN AGGREGATE REPLACEMENT: APPLICATION AT PEKAN, PAHANG, MALAYSIA

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We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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DEDICATION

Specially dedicated to my beloved parents,

To my beloved siblings,

A.prof. Dr.Wael, Eng. Ghassan and Dr. Bashar,

To my beloved supervisor,

Dr. Nadiatul Adilah Binti Ahmad Abdul Ghani,

To my beloved Co-supervisor,

A.prof Dr. Ramadhansyah Putra Jaya

To my friends and coursemates,

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For all their encouragement, patience, and unconditional support

Thank you so much, only ALLAH can repay all of your kindness

Also dedicated to,

those who have lost their beloved ones during flood session in Pekan , Pahang 2007 and everywhere in this universe.

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ABSTRAK

Banjir adalah bencana alam yang paling besar yang menjejaskan 4.9 juta orang dan menimbulkan kerosakan bernilai beberapa juta setiap tahun di Malaysia. Kira-kira 29,720 Km^2 atau 9% kawasan tanah negara terdedah kepada banjir. Bandar Pekan terletak di tebing Sungai Pahang, sering mengalami kerosakan ekonomi dan pemusnahan fizikal yang disebabkan oleh banjir. Kajian ini adalah cuba mengenalpasti konkrit yang boleh digunakan dengan berkesan di Jalan Kuantan - Pekan yang mempunyai kadar larian air yang tinggi. Matlamat penyelidikan ini adalah untuk mengelakkan atau sekurang-kurangnya meminimumkan larian langsung pada turapan dengan mengekalkan ciri semulajadinya. Kajian ini diproses dalam dua tahap; Tahap pertama adalah mendapatkan rekabentuk campuran yang terbaik daripada hasil awal yang terdiri daripada 48 sampel sampel konkrit padu dengan dimensi ketinggian 100mm berdasarkan ujian kekuatan mampatan 7 hari. Kemudian, nisbah agregat dan nisbah yang berlainan akan diuji untuk memilih kekuatan mampatan yang tinggi untuk digunakan pada peringkat ke-2. Di peringkat ke-2, terdapat 12 sampel konkrit silinder dengan dimensi diameter 200mm * 100mm. Sanga keluli turut digunakan di peringkat ke-2 selain agregat granit. Malah, sanga keluli terlibat dalam tiga peratusan berbeza iaitu 50% Slag Steel dan 50% Granit, 30% Slag Steel dan 70% Granit dan 70% Slag Steel dan 30% Granit. Kadar penyusupan juga akan diuji mengunakan ujian kebolehtelapan. Sebaliknya, aspek utama yang menimbulkan halangan pada laluan pejalan kaki iaitu intensiti hujan akan dikenalpasti. Oleh itu, Kala Kekerapan Pengagihan Intensiti IDF hujan di Stesen Rumah Pam Pahang Tua di tapak 3533102 akan dibangunkan dengan menggunakan MSMA edisi ke-2 untuk dibandingkan dengan kadar penyusupan hasil konkrit.

ABSTRACT

Floods are the most significant natural disasters which affect 4.9 million people and inflict damage worth of several million every year in Malaysia. About 29,720 Km^2 or 9% of the land area of the country is prone to flooding. Pekan town is located on the banks of the Pahang River, regularly suffers both economic damages and physical destructions caused by the floods. This study is a try to determine the suitable pervious concrete that can be used effectively at Jalan Kuantan – Pekan which experienced high direct runoff. The goal of this research is to prevent or at least minimizing hastily the direct runoff on the pavement and preserve their natural characteristics. Indeed, this study is progressed in two stages; 1st stage is obtaining the best mix design out of the preliminary result which consist of 48 samples of cubic concrete samples with dimension of 100mm based on 7 days compressive strength test. Then, different proportion of aggregate and water/cement ratio will be tested in order to select the highest compressive strength to be used in the 2nd stage. In the 2nd stage, there are 12 samples of cylindrical concrete with dimension of 200mm in height *100mm in diameter. Steel slag is used in the 2nd stage besides the granite aggregate. In fact, the steel slag is involved in terms of three different of percentage as 70% Granite and 30% Steel Slag, 50% Steel Slag and 50% Granite and 30% Granite and 70% Steel Slag. Also, Infiltration rate will be tested throughout permeability test. Oppositely, the main aspect that generating the obstacle on the pavement which is the rainfall intensity will be identified. Thus, Intensity Distribution Frequency IDF curve of rainfall of Rumah Pam Pahang Tua Station at site 3533102 will be developed by using MSMA 2nd edition to be compared with infiltration rate results of pervious concrete and to determine the suitability of the pervious concrete to be used.

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LIST OF SYMBOLS

σ Sigma represent the compressive strength in Mpa , N/mm^2

P Pressure represent the maximum load on surface area, KN

A Area

i Average rainfall intensity $\left(\frac{\text{mm}}{\text{hr}}\right)$;

T Average Recurrence Interval ARI

d Storm duration (hours)

λ, κ, θ and η fitting constant dependent on the raingauge locationof MSMA (Figure 4.24)

LIST OF ABBREVIATION

WSUD	Water Sensitive Urban Design
DID	Department of Irrigation and Drainage
PCPC	Portland Cement Pervious Concrete
EPA	United States Environmental Protection Agency
BMP	Best Management Practices
NRMCA	National Ready-Mix Concrete Association of Malaysia
CIP	Convergence Indicator Plot
BS	British Standard
ASTM	American Standard Testing Machine
IDF	Intensity Duration Frequency
ARI	Average Recurrence Interval

LIST OF EQUATIONS

CHAPTER 1

INTRODUCTION

1.1 Background

Historically, Malaysia has not experienced any of natural disasters in terms earthquake or volcanoes or typhoons. However, the most common natural disaster encountered in Malaysia is flood due to variety of reasons; for example, considering even man-made disasters (e.g fall down of a dam) as proper as different grades of precipitation (heavy rain, snow, and hurricane) would probably be an evoke to generate flood. Flood may not be a natural catastrophe that imposes as impressive damages as earthquakes or hurricanes do. However, it has a massive impact on the community that leads to lose property and life.

Pavements are beneficial and allow current human society to move easily. In contrast, impervious surfaces increase the rate and volume of storm water runoff and also prevent rainfall from either infiltrating into or evaporating from the natural soil (Haselbach, 2011). Thus, there is a need for a replacement to impervious pavement that will help in decreasing the stormwater on pavements. Porous concrete additionally recognized as pervious, permeable or no fines concrete is made up of coarse aggregate, components and cement with little to no fine aggregate. Porous concrete, as recommended through its many names and absence of fine aggregate particles, has excessive porosity and excessive permeability in contrast to preferred concrete. This allows water to infiltrate thru the concrete and the permeable sub-base layers and into the floor below. The infiltration ability depends on the plan and depth of the pervious concrete and the permeable sub base layers underneath it (Xu et al., 2018).

Pervious concrete is developing in reputable and increasing number of used products for the development of vehicle parks, foot paths. Indeed, it will drive approaches to take away direct runoff and to help stormwater drainage. However, pervious concrete has never been used in Malaysia, even though it has been used in Europe and china. For example, Beijing, China for the 2008 Summer Olympics and North Gay Avenue - The City of Portland, Oregon in USA.

Due to persevering with urbanization, the magnitude of city stormwater is growing. Urbanization creates additional impenetrable surfaces such as buildings, roads, foot paths and vehicle park all of this has created a wide catchment area for stormwater runoff. The excessive runoff will increase pressure on the existing stormwater technology and receiving waters which leads to flooding. Water sensitive urban design (WSUD) takes environmental, economic, visible science and social elements into account to ensure city water administration is touchy to natural hydrological and ecological processes (Lian, 2010). WSUD is growing in city structure as water resources turn out to be greater and really essential in today's society.

Pervious concrete is commonly used as an initially drainage machine to soak up direct runoff. This relieves the stress on storm water drains and can minimize the need for kerbing and expansive storm water structures which can assist to decrease stormwater infrastructure costs (Öz, 2018). By penetrating water through pervious concrete, it can help filling up nearby floor water sources and water surround root structures for timber and vegetation which would not have obtained any water from an impermeable floor. Minor use of porous concrete is to seize the quantity of city runoff and pollutants flowing into natural waters.

Pervious concrete also filters contamination out of the runoff earlier than it reaches downstream receiving waters. The first water that runs off all through a rainfall event consists of the highest load of pollution. The porous concrete lets this pollutant run off to go with the flow via it and infiltrate the floor below, filtering the water instead of it is flowing straight into a stormwater drain. Porous concrete is viewed to be a green and sustainable alternative material for constructing applications where there are high areas of impermeable surfaces which create high a quantity of stormwater runoff and pollutant runoff. The excessive void ratio and permeability in turn minimizing the strength and durability of the concrete (Chen, 2013).

Majority of the experimental carried out performed on porous concrete has targeted on increasing the strength of the concrete while retaining a suited permeability rate. This has been completed via altering the concrete combination designs to achieve the most appropriate combination with the aid of trailing a number of water-cement ratios, aggregate-cement ratios, aggregate type and dimension and compaction techniques. While these elements are very essential there is only minimal study on the durability of porous concrete. Durability is the potential to withstand time, abrasion, the surroundings or any technique of deterioration. The concrete wants to be capable to filter the required drift of water and be in a position to guide the respective loads of its application.

1.2 Problem Statement

Transportation are taking part in an essential position in any development of a community seeing that the rate motion made by either vehicle or humans represents how energetic and active the community is. To increase effectivity and productiveness of a community transportation in a high secured condition. Thus, an energetic society can be hastily developed and be developed faster.

However, the presence of high depth of direct runoff on highways or roads is performing as boundaries in opposition to vehicle. Moreover, many of the highways are dealing with this trouble in varies aspects such as high intensity of rainfall or direct runoff from high landscape. Indeed, this direct runoff is paralyzing the transportation of vehicle particularly throughout evacuation time. A problem like this should be highlighted in order to be solved smoothly.

Figure 1.1 Jalan Kuantan - Jalan Pekan flood

Figure 1.2 Liputan Banjir in Pekan, Pahang

REFERENCES

A publication of the national ready mixed concrete association. (2006).

Abdel, F., & Mohamed, A. (2013). Properties of Portland Cement Pervious Concrete, (June).

About the Author. (n.d.).

Abu Bakar, B. H., Ramadhansyah, P. J., & Megat Azmi, M. J. (2011). Effect of rice husk ash fineness on the chemical and physical properties of concrete. *Magazine of Concrete Research*, *63*(5), 313–320. https://doi.org/10.1680/macr.10.00019

Ahmedzade, P., & Sengoz, B. (2009). Evaluation of steel slag coarse aggregate in hot mix asphalt concrete. *Journal of Hazardous Materials*, *165*(1–3), 300–305. https://doi.org/10.1016/j.jhazmat.2008.09.105

Awang, H., Daud, Z., & Hatta, M. Z. M. (2015). Hydrology Properties and Water Quality Assessment of the Sembrong Dam, Johor, Malaysia. *Procedia - Social and Behavioral Sciences*, *195*, 2868–2873. https://doi.org/10.1016/j.sbspro.2015.06.409

Chen, Y., Wang, K., Wang, X., & Zhou, W. (2013). Strength, fracture and fatigue of pervious concrete. *Construction and Building Materials*, *42*, 97–104. https://doi.org/10.1016/J.CONBUILDMAT.2013.01.006

Choudhari, K., Panigrahi, B., & Paul, J. C. (2014). Simulation of rainfall-runoff process using HEC-HMS model for Balijore. *International Journal of Geomatics and Geosciences*, *5*(2), 253–265. https://doi.org/Code : EIJGGS5021

Concrete Pavement Technology Center, N. (2006). Strategic Plan for Improved Concrete Pavement Surface Characteristics, (July).

Crouch, C. O. L. I. N. (2004). The State and Innovations in Economic Governance, 100–116.

Das, S., & Shah, M. I. (2017). REVIEW PAPER : APPLICATION OF NANOTECHNOLOGY IN SMART CIVIL, *2*(4), 157–163.

El-maaty, A. E. A. (2016). Establishing a Balance Between Mechanical and Durability Properties of Pervious Concrete Pavement, *1*(2), 13–25. https://doi.org/10.11648/j.ajtte.20160102.11

Geoffroy, G. L., Carlson, S. L., & Engelbrecht, D. M. C. (2006). NATIONAL ARCHITECTURAL ACCREDITING BOARD ARCHITECTURAL PROGRAM REPORT 2006 IOWA STATE UNIVERSITY, 1–91.

Government of Malaysia Department of Irrigation and Drainage Urban Stormwater Management Manual for Malaysia MSMA 2 nd Edition. (n.d.).

Haselbach, L., Boyer, M., Kevern, J., & Schaefer, V. (2011). Cyclic Heat Island Impacts on Traditional Versus Pervious Concrete Pavement Systems. *Transportation Research Record: Journal of the Transportation Research Board*, *2240*, 107–115. https://doi.org/10.3141/2240-14

Huang, B., Wu, H., Shu, X., & Burdette, E. G. (2010). Laboratory evaluation of permeability and strength of polymer-modified pervious concrete. *Construction and Building Materials*, *24*(5), 818–823. https://doi.org/10.1016/J.CONBUILDMAT.2009.10.025

Ibrahim, A., Mahmoud, E., Yamin, M., & Chowdary, V. (2014). Experimental study on Portland cement pervious concrete mechanical and hydrological properties. *Construction and Building Materials*, *50*, 524–529. https://doi.org/10.1016/j.conbuildmat.2013.09.022

Jiang, C., Zhou, X., Huang, S., & Chen, D. (2016). Influence of polyacrylic ester and silica fume on the mechanical properties of mortar for repair application. *Advances in Mechanical Engineering*, *9*(1). https://doi.org/10.1177/1687814016683856

Kang, H. M., & Yusof, F. (2012). Homogeneity Tests on Daily Rainfall Series in Peninsular Malaysia. *Int. J. Contemp. Math. Scie.*, *7*(1), 9–22.

Lian, C., & Zhuge, Y. (2010). Optimum mix design of enhanced permeable concrete - An experimental investigation. *Construction and Building Materials*, *24*(12), 2664–2671. https://doi.org/10.1016/j.conbuildmat.2010.04.057

Maslehuddin, M., Sharif, A. M., Shameem, M., Ibrahim, M., & Barry, M. S. (2003). Comparison of properties of steel slag and crushed limestone aggregate concretes. *Construction and Building Materials*, *17*(2), 105–112. https://doi.org/10.1016/S0950-0618(02)00095-8

Öz, H. Ö. (2018). Properties of pervious concretes partially incorporating acidic pumice as coarse aggregate. *Construction and Building Materials*, *166*, 601–609. https://doi.org/10.1016/J.CONBUILDMAT.2018.02.010

Resources, F. (2006). Global Hydrological Cycles and, (August), 1068–1073.

Rutkevičius, M., Mehl, G. H., Paunov, V. N., Qin, Q., Rubini, P. A., Stoyanov, S. D., & Petkov, J. (2013). Sound absorption properties of porous composites fabricated by a hydrogel templating technique. *Journal of Materials Research*, *28*(17), 2409–2414. https://doi.org/10.1557/jmr.2013.194

Savun, B., Phillips, B. J., & Phillips, B. J. (2013). Democracy , Foreign Policy , and Terrorism, *53*(6), 878–904.

Suhaila, J., & Jemain, A. A. (2012). Spatial analysis of daily rainfall intensity and

concentration index in Peninsular Malaysia. *Theoretical and Applied Climatology*, *108*(1–2), 235–245. https://doi.org/10.1007/s00704-011-0529-2

Tennis, P. D., Leming, M. L., & Akers, D. J. (2004). *Pervious Concrete Pavements*. *Portland Cement Association, Skokie, Illinois, and National Ready Mixed Concrete Association, Silver Spring, Maryland, USA*. Retrieved from http://myscmap.sc.gov/marine/NERR/pdf/PerviousConcrete_pavements.pdf

Tong, B., & Tong, B. (2011). AMD-Clogging effects of portland cement pervious concrete.

Uju, I. (2010). A Study Of The Strength Of Pervious Pavement Systems.

Van Dam, T. (2016). Ensuring Durability of Concrete Paving Mixtures Part I: Mechanisms and Mitigation, (April), 12.

Wan Zin, W. Z., Jamaludin, S., Deni, S. M., & Jemain, A. A. (2010). Recent changes in extreme rainfall events in Peninsular Malaysia: 1971-2005. *Theoretical and Applied Climatology*, *99*(3–4), 303–314. https://doi.org/10.1007/s00704-009-0141-x

Wang, G. (2010). Determination of the expansion force of coarse steel slag aggregate. *Construction and Building Materials*, *24*(10), 1961–1966. https://doi.org/10.1016/j.conbuildmat.2010.04.004

Weng, C. N. (2005). Sustainable management of rivers in malaysia: Involving all stakeholders. *International Journal of River Basin Management*, *3*(3), 147–162. https://doi.org/10.1080/15715124.2005.9635254

Wiegand, P. (2006). Evaluation of U . S . and European Concrete Pavement Noise Reduction Methods, *00042*(July).

Xu, G., Shen, W., Huo, X., Yang, Z., Wang, J., Zhang, W., & Ji, X. (2018). Investigation on the properties of porous concrete as road base material. *Construction and Building Materials*, *158*, 141–148. https://doi.org/10.1016/j.conbuildmat.2017.09.151